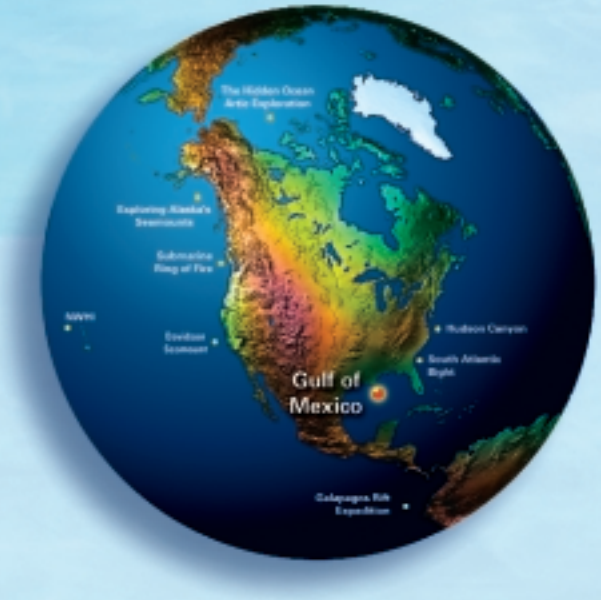
DISCOVERY IN AMERICA'S SEA: THE 2002 MISSION TO THE GULF OF MEXICO



The discoveries of chemosynthetic ecosystems, such as those at hydrothermal vents and cold methane seeps, have been hailed as some of the most important findings of the past century. The discovery of tubeworms, ice worms and the array of associated fauna within these ecosystems has opened a new chapter in the history of life on Earth.

The Gulf of Mexico, home to extensive oil and gas lease tracts, has already been the site of numerous geologic studies and surveys. Due to this extensive background data, developed over five decades of geophysical surveys and piston coring, scientists have excellent information to use in planning new explorations. While much is known about the geologic foundation of the Gulf, surprisingly little is known about its deep ecosystems and associated biology.

An interdisciplinary team of scientists used Harbor Branch Oceanographic Institution's (HBOI) research vessel *Seward Johnson* and the *Johnson Sea-Link* submersible in 2002 to explore the communities of animals found around deep sea oil seeps in the Gulf of Mexico. The expedition team of ecologists, larval biologists, physiologists, microbiologists, geologists, geochemists, and oceanographers came from a variety of different academic institutions, as well as several foreign countries. Together, they explored several new sites in search of animal communities associated with oil and gas seepage, and carried out experiments and sample collections that have opened up new windows of understanding on the lush deep sea Gulf communities that thrive in total absence of sunlight.

This three part expedition, using over two months of ship time, over 40 submersible days, and 60 hours of bottom time, resulted in one of the most interdisciplinary studies ever undertaken of the deep sea life of the Gulf of Mexico. One of the most exciting findings of the expedition was the discovery of a new species of tubeworm. Another was the discovery of a large deep-coral reef associated with the carbonate rocks produced at one of the seep sites.

Cold-seep tubeworms (sometimes as long as 10 feet) are abundant at the cold seeps in the Gulf of Mexico. These worms are closely related to other giant tubeworms found around deep sea hydrothermal vents. These bizarre worms have no mouth, gut, or digestive tract and obtain their food from special symbiotic bacteria that live inside their bodies in an organ called the trophosome, which is basically a cavity full of bacteria. These bacteria are chemosynthetic, using hydrogen sulfide present in cold-seeps and hydrothermal vents, as an energy source. By staining tubeworms and observing their growth over years, scientists have determined that the Gulf of Mexico cold-seep tubeworms are among the longest-lived animals known on Earth. They can easily live for more than 200 years.

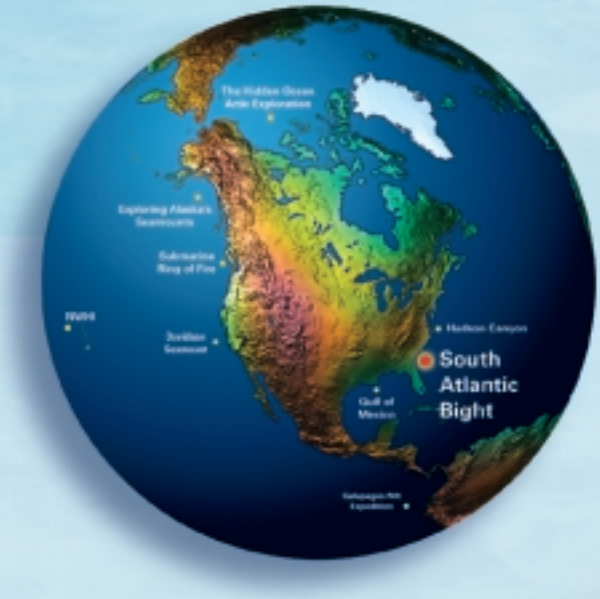
One of the most unusual sites explored during the expedition was a site called the Brine Pool, which is a small hypersaline lake on the seafloor with a distinct surface and shoreline. It exists within the ocean because its water has a higher density than the surrounding seawater. The Gulf of Mexico contains brine lakes ranging from 1 m across to 20 km long. The Brine Pool was created by the dissolution of buried salt deposits formed during a time when the Gulf of Mexico was dry land. Now, broken into two large sheets, the movement of this salt sculpts the seafloor and creates unique habitats.

During the first leg of this expedition, the highest priority was to test equipment developed especially for exploration in the Gulf, and to initiate experiments that would be completed on later cruises, such as tubeworm age and growth studies, and a study on mussel settlement in brine pools. Several new cold-seep sites were also briefly explored and sampled before inclement weather forced the early termination of this leg. The main objectives for the second leg were to conduct submersible dives on methane hydrate sites to collect hydrates and sediments. During the third leg, scientists focused on the reproductive biology of seep animals and also explored and sampled several of the new cold-seep sites that were missed during the first leg.

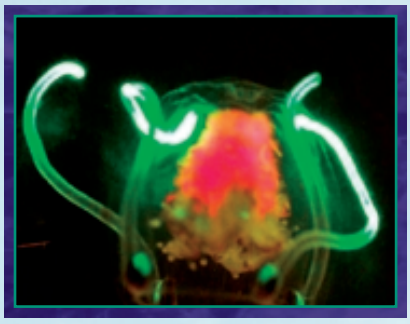
Brine pools and microbial mats were also sampled, as were planktonic organisms. The ever-elusive ice worms were sought out and collected for physiological analysis. The preliminary examination of the collections suggests that at least three additional species that are new to science were collected with the tubeworms. Another facet of this expedition incorporated both ship and submersible operations and involved mapping the seafloor. Several potential new sites to be visited on subsequent missions were identified using this dual-sonar approach.

One of the major surprises of deep sea biology in the past 50 years has been the discovery that many species living in deep cold waters breed during only one season of the year. Although seasonal breeding is common in shallow water, it is unexpected in the deep sea, where seasonal changes are not obvious. The Gulf of Mexico expedition team studied the reproduction and embryology of seep animals, including mussels, clams, snails, crustaceans, tubeworms and several other kinds of worms. The animals were collected for studies of feeding biology, community structure and diversity, and larval physiology and growth. Sediment was collected so that scientists could learn more about the unique microscopic animals that live between the sand grains in this extreme environment. ■

EXPLORING LIFE ON DEEP REEFS: DISCOVERY IN THE SOUTH ATLANTIC BIGHT



Since the mid-20th Century, NOAA and its predecessor agencies (e.g., the Bureau of Commercial Fisheries) have explored the habitats and resources off the coast of the southeastern United States. The continental shelf and shelf edge from Cape Hatteras to Cape Canaveral, known as the South Atlantic Bight, has long been known by area fishermen to support large populations of fish in its submerged rocky reef habitat. Fishery research vessels have conducted fish population surveys in the area, beginning in the 1950's, using trawl nets towed along the bottom of the ocean floor. These early surveys found concentrations of snappers, groupers and other economically valuable fishes associated with rocky outcrops and other hard-bottom reefs on the continental shelf. However, scientists know that fish caught in a trawl net reveal little about the biological interactions, the habitat, the community structure and the overall ecology of the region. Populations of economically valuable reef fishes have been in decline for at least two decades in the South Atlantic Bight, leaving scientists with an urgent need to apply new tools and methods for understanding this vital ocean region.



In July and August of 2002, NOAA and an interdisciplinary group of investigators using Harbor Branch Oceanographic Institution's research vessel *Seward Johnson and the Johnson Sea-Link* submersible, explored deep reef habitats off the southeastern United States. These understudied habitats, peppered along the continental shelf and slope between North Carolina and Florida, are critical ecosystem links within the South Atlantic Bight region. This expedition extended exploration efforts into unexplored areas, and fostered collaboration on developing new ideas for habitat and resource protection.

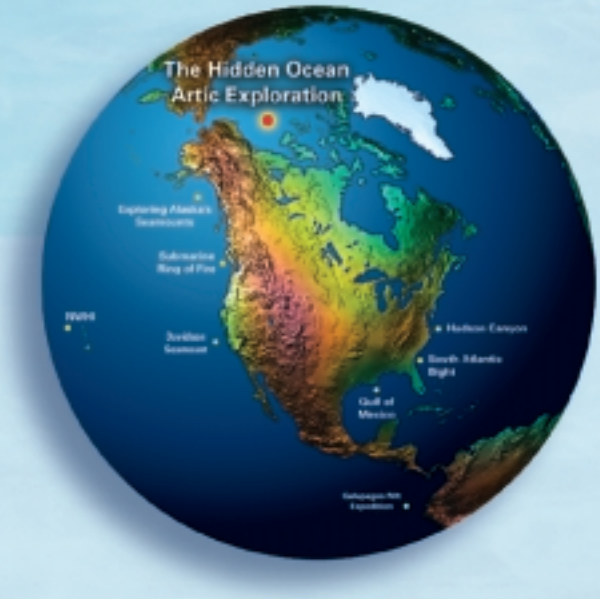
Employing high-resolution sidescan sonar, 48 submersible dives totaling over 120 hours of bottom time, and traditional sampling techniques, the science team located and investigated deep-water reef and hard-bottom habitats. Scientists collected information to characterize these areas in terms of reef morphology, geology, biology, and ecology. Observers noted a transition in these communities based on latitude, depth, and the position of the reefs in relation to the Gulf Stream.

During the expedition, the team distinguished several discrete types of reef habitat and explored a series of reefs positioned along the edge of the continental shelf, on the upper slope and on the Blake Plateau, approximately 80-100 km offshore at a depth of 1200 m. These reefs were found to contain a wide variety of deepwater coral species and associated biota. In even deeper water, researchers discovered monotypic stands of *Lophelia* and *Dendrophelia* corals. Observations made at two reefs separated by 100 km indicated that completely different communities were utilizing the same type of habitat. Further research on both of these habitat types is critical since little is known about them, their function, or their overall health. Researchers plan to use the information collected during this mission as a complement to historical data sets, providing natural resource managers with more information for making effective decisions.

With over 200 biological samples of deep sea organisms collected at the site, researchers observed a richer abundance and higher diversity of species as compared to information in existing literature. The team also collected several unidentified species of sponges and octocorals.

Scientists also witnessed sightings of the lionfish, *Pterios volitans*, a venomous invasive species native to western Pacific waters. This fish species had never been observed in waters this deep along the Atlantic coast until this year. The species appears to be numerous, widespread, and well established; its impact is unknown. ■

THE HIDDEN OCEAN: EXPLORATIONS UNDER THE ICE OF THE NORTH AMERICAN ARCTIC



Deep within the Arctic Ocean lies the isolated, more than two-mile deep Canada Basin, which reaches from Greenland and North America to Russia. Covered by ice and shrouded by total darkness during the winter, the Canada Basin has been left largely unexplored. What little is known about this area is limited to what the human eye can detect from a passing icebreaker or occasional satellite data. Limited efforts have been made to provide longer-term observations from such facilities as the drifting ice island T-3 and periodic Russian North Pole ice camps. Some data collected for national defense purposes are now available, and are providing a better picture of the bathymetry and circulation patterns of the Arctic Ocean. Still, the deeper portions of this northern ocean, and areas far from land-based facilities, remain largely unknown.

During the 2002 summer field season, NOAA Ocean Exploration participated in its first mission to a polar ocean. In August, an international team of 46 scientists from Canada, China, Japan and the United States participated in a collaborative effort to explore the frigid depths of the Canada Basin. The mission objectives were to take a first census of life from the sea ice surface down to the seafloor and measure the physical and geochemical properties in different regions of the basin. The physical oceanography of the Canada Basin is of interest because it is the last basin of the Arctic Ocean to receive warmer and fresher waters of Atlantic origin.

Inaccessibility due to severe ice conditions and extreme depth make the Canada Basin one of the Arctic Ocean's least known areas. Underwater mountain ranges border the western and northern fringes of the Basin. Waters in the depths remain at fairly constant temperatures, unfrozen year-round. Deep below the protective ice cover, there is a diversity of life, most of which has never been studied by researchers. Due to the remote and extreme physical environment, migration of life in and out of the area may be greatly limited. Consequently, some scientists believe the basin could be an 'Isolated Eden,' harboring undiscovered organisms, including extremophiles – novel organisms specially adapted to survive in harsh environments.

NOAA scientists joined members of the Canada-Japan Joint Western Arctic Climate Study (JWACS) onboard the Canadian Coast Guard icebreaker, *Louis St. Laurent.* While JWACS studied the physical and chemical oceanography of the Canada Basin, United States scientists used an ecosystem approach to explore what lives in and under the sea ice, as well as in the mid-water and bottom habitats.

In nine ROV dives totaling over 50 hours under water, combined with six SCUBA dives, scientists became polar explorers examining the hidden world of life in the Basin. From intricate microscopic organisms found in brine channels running through the ice to creatures that live on the sea bottom, the

science team studied the relationships between pelagic and benthic communities. They investigated the manner in which food energy is transferred from the surface of the ice, through the water column, and to the bottom of this harsh environment. In addition, they will analyze bottom sediments to determine their chemical makeup, as well as help reconstruct the climatic history and paleo-ecological events that formed the region. Three long-term moorings were also successfully deployed. These instruments will relay information about the temporal changes in ice thickness, current speed and direction, temperature and salinity over a two-year period.

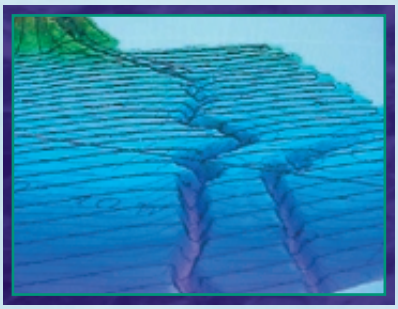
The international team looked at life throughout the entire water column. By combining these 'slices of life' with the physical and chemical research, scientists will have a look at the ecosystem structure of the basin. Preliminary findings include: the potential discovery of a new species of jellyfish; successful culturing of novel microorganisms; and new questions about the rates of reproduction in the Arctic. This exploration also provided a baseline for scientists to measure future effects of potential climate change.

The Arctic expedition also enabled the successful development and deployment of a highly portable remotely operated vehicle (ROV). Most deep submergence assets, though extraordinarily productive, still remain prohibitively expensive for scientists and other non-military or industrial groups. The only way to extend these capabilities to the wider community is to reduce their operation, transport and maintenance costs. The successful deployment of the Deep Sea Systems International, Inc. *Global Explorer* ROV to 3,000 m during the Arctic expedition provides hope that the cost for these assets is declining.

Hundreds of live cultures of organisms collected during the mission are being assayed under a variety of extreme conditions. One newly discovered microorganism grows solely on hydrocarbons at –1 degree C. This microbe may be a significant organism for bioremediation at low-temperatures. Further studies will verify if this or other organisms collected during the mission are new to science. ■

HUDSON CANYON 2002

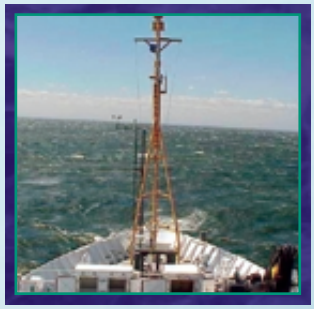
The Hudson Submarine Canyon is an ancient extension of the Hudson River Valley and is the largest submarine canyon on the eastern margin of North America. This unique region, extending over 400 nautical miles seaward from the New York/New Jersey Harbor and across the continental margin, connects the pulse of New York with the deep ocean. The Hudson Canyon is a pathway from land to sea in the heart of one of the largest metropolitan areas in the world. Scientists and resource managers have been curious about novel deep sea creatures that could potentially live in the canyon and about how runoff from the major cities in New York and New Jersey may impact the deep Atlantic Ocean. In order to address important questions like these, the Hudson Canyon must first be mapped in greater detail. High-resolution seismic and side scan sonar systems have proven to be immensely important to scientists studying the deep sea. But looking into the detailed profile of submarine canyons and trench walls is difficult, even using the advanced technology now available.

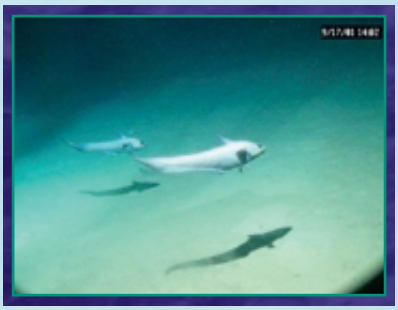


Using the largest vessel in the NOAA fleet, the *Ronald H. Brown*, and a high-resolution multibeam mapping system, investigators from NOAA, USGS, Rutgers University, and Woods Hole Oceanographic Institution mapped a significant portion of the Hudson Canyon during the 2002 summer field season. In addition to the mapping efforts, a research group from New York University at Stony Brook is preparing to analyze water samples collected during the cruise in search of evidence of methane vents on the seafloor and gas hydrates buried beneath the sediments.

Until the evolution of modern underwater mapping tools, charts were made by lowering weighted lines into the water at successive individual points. Today, however, the seafloor is remotely mapped using side scan sonar and high resolution seismic-reflection profiling. Seafloor mapping surveys provide a sophisticated and highly detailed picture of the seafloor and even the underlying geology by transmitting a series of acoustic pulses that are reflected off the ocean bottom and subsurface layers. Thus, scientists make improved maps of the ocean by seeing what the ocean sounds like.

Another mapping tool now available to scientists is technology that is used to process, archive and develop the geographic information while at sea. Recent advances in swath bathymetry and side scan sonar make it possible to create dynamic, three-dimensional maps at sea. For this expedition, multibeam sonar was used. This approach produced soundings not only along the ship's track, but also for significant distances perpendicular to it, thus providing a "swath" of soundings. This ability to collect side scan sonar data at the same time as swath bathymetry and sub-bottom data has greatly improved a scientist's ability to

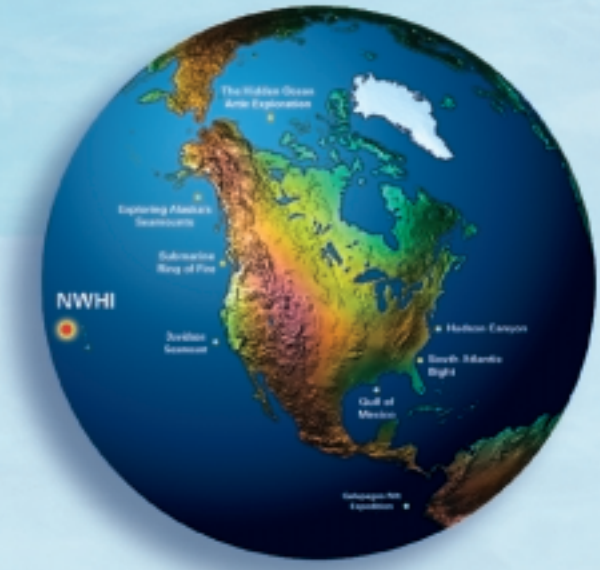




interpret the seafloor geography. Using these tools in combination gives us a new set of technological "eyes" to see features in the ocean never before distinguished.

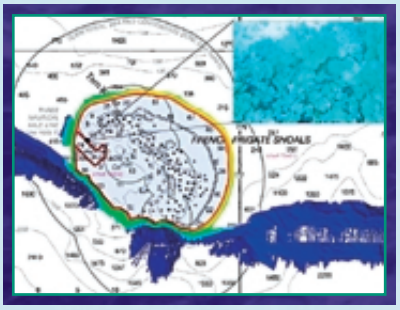
The main objective of this expedition was to map areas of the continental slope and rise to the east and west of the Hudson Canyon, and merge this data with existing multibeam coverage to produce the first coherent high-resolution bathymetric map of the Hudson Canyon region. This objective was met with the successful collection of data in a 6,600 square nautical mile area in the Canyon, contributing significantly to our understanding of this region. The second major objective of this expedition was to search for methane-venting zones through in-depth chemical analysis of water samples. Water samples are currently being analyzed to determine where and how widespread methane 'plumes' are in the Hudson Canyon, and to find the sources of methane in the area. The results of this expedition will be used to determine how long-term geological processes have shaped the Hudson Canyon, and this mapping effort will assist oceanographers in the future as they explore the deep ocean for new organisms, search for novel energy resources, and determine how our actions on land impact the deep sea. ■

MAPPING AND EXPLORATION IN THE NORTHWESTERN HAWAIIAN ISLANDS

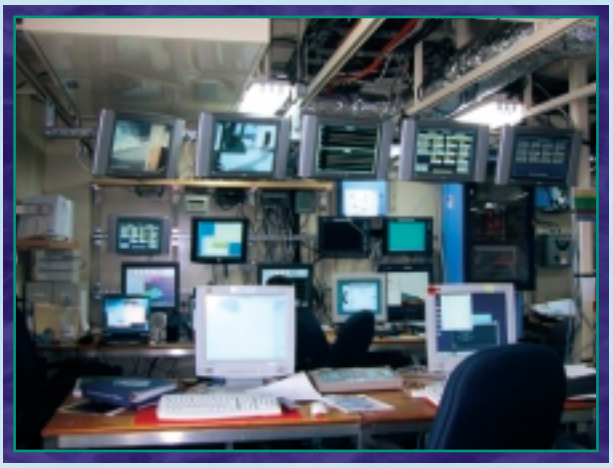


The Northwestern Hawaiian Islands (NWHI) extend 1,200 nautical miles to the northwest of the main Hawaiian Islands and cover an area longer than the State of California. This area has remained virtually unexplored as it is vast and remote. The recent establishment of the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve requires accurate assessments of reefs and other submerged features existing in the NWHI ecosystem.

In 2002, the Northwestern Hawaiian Islands were the focus of two collaborative mapping missions involving scientists from NOAA and the University of Hawaii, Hawaii Undersea Research Laboratory (HURL). Both expeditions used research vessels home ported in Hawaii: the R/V *Ka'imikai-O-Kanaloa (K-O-K),* and the new coastal and deep ocean mapping vessel, the R/V *Kilo Moana*. To the scientists studying this unexplored wonder, it is critical to have updated nautical charts. While charts of the area exist, many of them are outdated. New technologies on this cruise provided positioning accuracy that allowed scientists to conduct detailed mapping of the area. During the first mission, NOAA led a multidisciplinary team to map and explore the slopes of the Northampton Seamounts. These submerged volcanic mountains support unexplored habitats and fish assemblages. Recent data from satellite tags deployed on monk seals indicate that for unknown reasons, seals make frequent visits to the slopes of both seamounts. Previous work utilizing seal tracking data in another area led scientists to discover new beds of deepwater corals. The seal tracking data from the Northampton area provide scientists with an excellent indicator of deepwater coral beds and other unique habitats that otherwise would have been difficult to find. The primary purpose for the second mission was to conduct detailed multibeam mapping of banks and seamounts within the NWHI Coral Reef Ecosystem Reserve, specifically within the reserve preservation areas. This survey yielded detailed bathymetric maps of the ocean floor in areas where none existed.



A great deal of logistical and scientific planning preceded this expedition to make the cruise an overall success. The planning paid off as this expedition sparked several "first ever" accomplishments. This expedition deployed the first occupied submersible dive on the unexplored Northampton Seamounts. Scientists received their first view of this remote area through eight dives, totaling 29 hours of bottom time, in the University of Hawaii submersible, the *Pisces IV*. Also, five ROV dives, totaling 15 hours of bottom time, were made for observations and collections. Rare sharks were observed at the site including the first ever sighting of



a spongehead catshark *(Apristurus spongiceps)*, and the first photo documentation of a smalltooth sand shark *(Odontaspis ferox)*. Other fish and shellfish were observed on many of the dives, and species were observed in depth ranges and on habitats never before seen. The spectacular *Grammatonotus macrophthalmus* is a colorful reef fish that had only been seen by scientists once previously, and 10 individuals were observed during the team's second dive. Profiles of coral communities that inhabit the seamounts at various depths were observed, and collections were taken for further laboratory analysis.

Deep water habitat of the Hawaiian monk seal was also explored using the *Pisces IV* submersible. These dives allowed scientists to explore coral beds, study habitat characteristics, and see the deep ecosystem intact, rather than through pieces taken from trawl surveys. Using the ROV *RCV-150*, shallower coral beds and associated fauna were observed and sampled.

In addition to the many scientific discoveries of this mission, many scientists noted that an important piece of the expedition was the remarkable mapping capabilities of the *Kilo Moana*. An area of over 11,000 square nautical miles was mapped this year during the Northwestern Hawaiian Islands expedition. These maps give important details to resource managers and scientists to characterize habitat, accurately update nautical charts, and establish isobaths for the purpose of identifying boundaries. This high-resolution bathymetry also provides a basis of information for future exploration with occupied submersibles and ROVs.

This information provides a new baseline for ecosystem data in one of the world's least explored areas. ■

PROJECTS

BLACK SEA

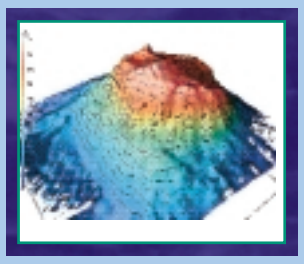
Supporting advancements in new ocean technology is a priority for NOAA's Office of Ocean Exploration. The latest expedition to the Black Sea, organized by Dr. Robert Ballard and supported by NOAA, used state-of-the-art technology to aid in the discovery of several shipwrecks, some of which appeared to be ancient, yet well preserved, off the coast of Bulgaria. One of the wrecks, a wooden ship about 40 feet long, was found July 30, when Ballard's Institute for Exploration team used a small manned submarine to dive on objects that were identified on an earlier mission. Another wreck, found August 1, appeared to be a Roman trade ship, and a third has not yet been identified. Ballard said an amphora, a tall jar used to transport commodities in the ancient world, was retrieved. Intact ancient wooden shipwrecks are extremely rare, however, in the Black Sea, organisms that commonly devour wooden ships in other bodies of water are not present below a depth of 450 feet, leaving most ships fully preserved. Ballard and his team plan to return to the Black Sea next year on a major expedition that will pioneer deepwater archaeological excavation.

BOTTOM TRAWLING RESEARCH AND RECONNAISSANCE SURVEYING IN BRISTOL BAY

Bottom trawling effects are being studied in a shallow, soft-bottom area of the eastern Bering Sea. In 2001, OE and the National Marine Fisheries Service (NMFS) partnered to map twelve 10-mile long research corridors, each surveyed before and after trawling with commercial gear. To investigate the recovery process, these same corridors were resampled in 2002 during a 21-day cruise aboard the chartered fishing vessel *Ocean Explorer.* Surface-living organisms (epifauna), surficial sediments, and organisms living in the sediments (infauna) were sampled using research trawls and van Veen grab samplers. A high-resolution side scan sonar system was also deployed to study possible changes in physical characteristics of the seafloor as a result of trawling. A multidisciplinary team of scientists, technicians, and fishers from government, university, military, and industry sectors are collaboratively working on the study.

CENSUS OF MARINE LIFE: BIODIVERSITY OF BEAR SEAMOUNT:

While the geology of the New England Seamounts and their effects on the Gulf Stream have been extensively studied, few studies have looked at the communities of living organisms residing there. The first biological census ever undertaken at Bear Seamount, New England's most inshore seamount, was completed during this project. The objectives for this project were to explore the biodiversity in the vicinity of Bear Seamount by collecting organisms (especially fish and cephalopods) in bottom- and mid- water samples and to collect information on the distribution of cetaceans, particularly beaked whales and sperm whales, oceanographic features, and potential prey. Deep mid-water trawling at 20 different stations was very successful. Additionally, sets of mid-water samples were successfully collected in three slope/canyon areas where aggregations of toothed whales were encountered. Preliminary identifications indicate that about 183 species of fishes, at least 33 species of cephalopods, and 152 other types of invertebrates were collected from Bear Seamount during this cruise, data that resource managers, scientists and decision-makers need for appropriate resource stewardship.



CENSUS OF MARINE LIFE: DISCOVERING LONG DISTANCE MIGRATIONS AND DEEP DIVING BEHAVIOR FOR LARGE PELAGICS IN THE CENTRAL PACIFIC

A new tool for tracking the movements of large ocean fish is the pop-up satellite archival tag. These tags turn oceanic sharks, tunas, and billfishes into explorers, and give scientists new information about the habitats of fish whose migrations are now known to cover thousands of kilometers. This year, 26 pop-up satellite archival tags were deployed on bigeye and albacore tunas, moonfish (locally known as opah), and short-fin mako sharks during two cruises utilizing commercial longline fishery vessels. While only preliminary results are known at this point, there are several exciting findings. One of the moonfish tagged near in May left Hawaii about two weeks after tagging and traveled over 1,000 km northward in 10 days to the northern edge of the subtropical gyre where it stayed for four months. It was discovered to be living at depths of 200-400 m. Until this work, very little was known about the movement of the moonfish. Tags deployed on large bigeye tunas southeast of Hawaii, reveal that although they are frequently found inhabiting depths of 300-400 m, the tunas dive down to depths of 1,000 m, waters characterized by very low oxygen levels. It was previously thought that low oxygen waters were not a habitat for bigeye tunas, however our data suggest that while they can not stay in this low oxygen water for long periods, they can recover from the resultant oxygen deficit with frequent excursions to shallower depths.

CONTINUING THE LEWIS AND CLARK LEGACY

Complementing work done by OE in 2001, explorers spent four days off the coast of Oregon aboard the R/V *Thomas G. Thompson* to create a new, and highly detailed map of an area greater than 550 square nautical miles. The new map includes

details of the submerged paleo-shoreline located southwest of Newport, Oregon, that has never been seen before. One exciting observation from the new view of this ancient coastline is the apparent location of what would have been the mouth of the present-day Yaquina River Estuary, during the last glaciation (ca. 17,000 YBP). Seaward of the estuary is a wave-cut platform possibly representing the paleo-continental shelf. During the present day, the Yaquina River Estuary is one of the larger Oregon estuaries, and the location of a major commercial fishing port, Newport. Could this estuary have been the home of some of the first North Americans?

THE LINK PROJECT

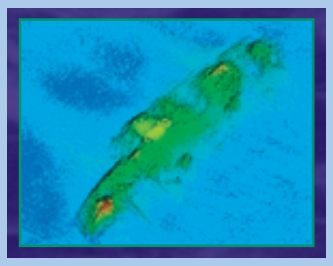
NOAA and NASA are investigating new opportunities for partnerships in exploration. Scientists, engineers, and explorers have much in common, and by crossing boundaries and working together, they can share solutions to some of sciences most important challenges. The Link Project 2002 captured the spirit of its namesake, renowned inventor Edwin Link, by convening an international symposium for ocean and space scientists and engineers in May 2002. This symposium, held at NASA's Kennedy Space Center, facilitated technology exchange between the ocean and space science and engineering communities through technical sessions. One season highlighted advancements in technology that may be of benefit to both ocean and space exploration. Another session described the role of technology in deep sea and interplanetary exploration and its potential to answer fundamental questions about the origin and distribution of life. Proceedings from the symposium were published in the Marine Technology Society Journal in August 2002. The Link Symposium was also the focus of an article in the June 2002 issue of "Nature."

MAPPING THE PUERTO RICO TRENCH

In September 2002, NOAA teamed up with scientists from USGS, and the University of New Hampshire's Center for Coastal and Ocean Mapping on board the NOAA R/V *Ronald H. Brown* to map a portion of the Puerto Rico trench. The Puerto Rico trench is associated with the most negative gravity anomaly on earth, and comprises the deepest region in the Atlantic Ocean with depths reaching more than 8400 meters. Yet, the bathymetry of the trench is known only in general terms, and the tectonic setting of the trench is not thoroughly understood. This lack of knowledge is a major problem for Puerto Rico and the Virgin Islands, as tectonically active regions, potentially generating tsunamis, are located very close to their coastlines. The major objective of this project was to develop the first coherent high-resolution bathymetric map of the Puerto Rico trench to be used as a platform for future studies of this unique and poorly understood region. This six-day survey resulted in the acquisition

of 7,475 square nautical miles of multibeam data, work which will continue in February 2003, with approximately 15 more days of surveying. Several new landslides and an active fault system were discovered through the high-resolution data acquired during the cruise.

NORMANDY



NOAA is proud of its role in supporting the Navy and the Naval Historical Center (NHC) in a historic survey of the waters adjacent to the beaches of Normandy. The NHC sought to obtain information on U.S. Navy losses during Operation Neptune, the Allied naval invasion on France's Normandy coast on June 6, 1944 (D-Day). Remote sensing and ROV instruments were used to locate and confirm the existence of U.S. Navy ships, vehicles and German beachhead structures. The areas were mapped using magnetometer and shallow water multibeam sonar technologies. The resulting discovery of more than 2,000 magnetic anomalies and over 800 sonar targets were integrated into a GIS database. The ROV phase of the project documented thirty-three targets deemed potentially significant to the interpretation of naval support in the American landing sectors, including the large transport vessel, *Susan B. Anthony.*

NORTHWEST GULF OF MEXICO HIGH RESOLUTION MAPPING

NOAA collaborated with the Minerals Management Service (MMS) and the U.S. Geological Survey (USGS) to map the northwest Gulf of Mexico using a high-resolution multibeam system. The data were acquired by the USGS using C&C Technologies' *R/V Ocean Surveyor,* and processed by USGS and the University of New Brunswick. Unique places such as Alderdice Bank, which has two basalt spires characterizing it as the Gulf's only known volcanic area, were fully surveyed. The survey resulted in detailed bathymetric maps of several geological areas including 12 formerly unknown features. NOAA's Flower Gardens National Marine Sanctuary used the mapping data to support submersible work the following month. By overlaying the submersible track lines over the bathymetric charts, the team dramatically increased the efficiency of their dives. They were able to use newer technology to explore several new areas and revisit old sites.

SIRENA

Seismic Investigation by REcording of acoustic waves in the North Atlantic (SIRENA). On May 17, 2002, NOAA teamed with scientists from both sides of the Atlantic on board the French research vessel *Le Suroit.* They sailed from Ponta Delgada, in the Portugese Azores, to deploy an array of six continuously recording hydrophones around the Mid-Atlantic Ridge north of the Azores. The acoustic data was not available in real time, but the instruments will be recovered in the summer 2003. The onboard data and resulting analyses will constitute an "acoustic exploration" of this important region of the global ocean. Anticipated acoustic activity includes earthquakes and possible volcanic activity from the Mid-Atlantic Ridge and Iceland, large whale calls, especially blue whales and humpback whales, and

new measurements of the noise impact of oil exploration around the Atlantic Basin. Some new phenomena that could be present in the data include landslides along the massive continental slopes around the North Atlantic or the sound of catastrophic release of submarine methane hydrates from these margins. Also, the array will be within range of permanent glaciers on Greenland and may be able to detect sounds associated with ice processes in that region.

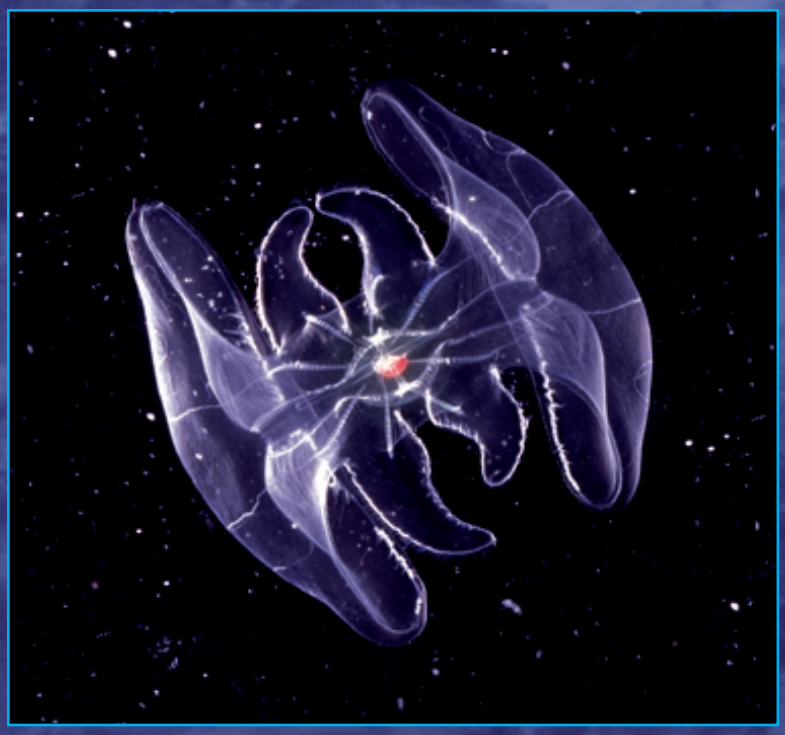
THUNDER BAY

The Thunder Bay National Marine Sanctuary was designated to help preserve an important part of America's maritime heritage. This is the second year of a partnership between NOAA and Dr. Robert Ballard's Institute for Exploration (IFE) to investigate shipwrecks at the site. The goal of this year's project was to use digital underwater video mounted on two remotely operated vehicles (ROV) to investigate shipwrecks and geological features the team located last year; the results were astounding. High definition digital video data were acquired on almost two-dozen wrecks, ranging from wooden schooners of the 1850's to 20th century steel freighters. The video data recorded detailed images of shipwright craftsmanship from an age when Great Lakes maritime commerce and trade were at their fullest. The ROVs also searched sinkholes and several other geologic features for evidence of human habitation prior to the refilling of the lake following the last Ice Age.

USS MONITOR

On August 6, 2002, after spending 140 years on the ocean floor, the turret of the USS *Monitor* was successfully raised by NOAA and the U.S. Navy. The turret was transported by barge to The Mariner's Museum in Newport News, Virginia for conservation and further excavation. The interior of the turret, filled with silt and coal, yielded many historical findings including two large Dahlgren cannons, a fully intact lantern, and a well-preserved leather boot. The remains of two sailors were also discovered, and were carefully transported to the U.S. Army's Central Identification Laboratory in Hawaii for proper treatment.

EDUCATION AND OUTREACH



REACHING OUT IN NEW WAYS

The oceans are the lifeblood of Earth. They cover 70% of the planet's surface, drive its weather, cleanse its atmosphere and ultimately fuel all living creatures. The increasing awareness that human existence on Earth is bound to the ocean is directly related to our expanding knowledge of ocean regions and processes. As cornerstones of the Ocean Exploration program and with 10% of its overall annual budget dedicated to education and outreach activities, OE strives to engage the broadest possible audiences in order to raise America's environmental literacy.

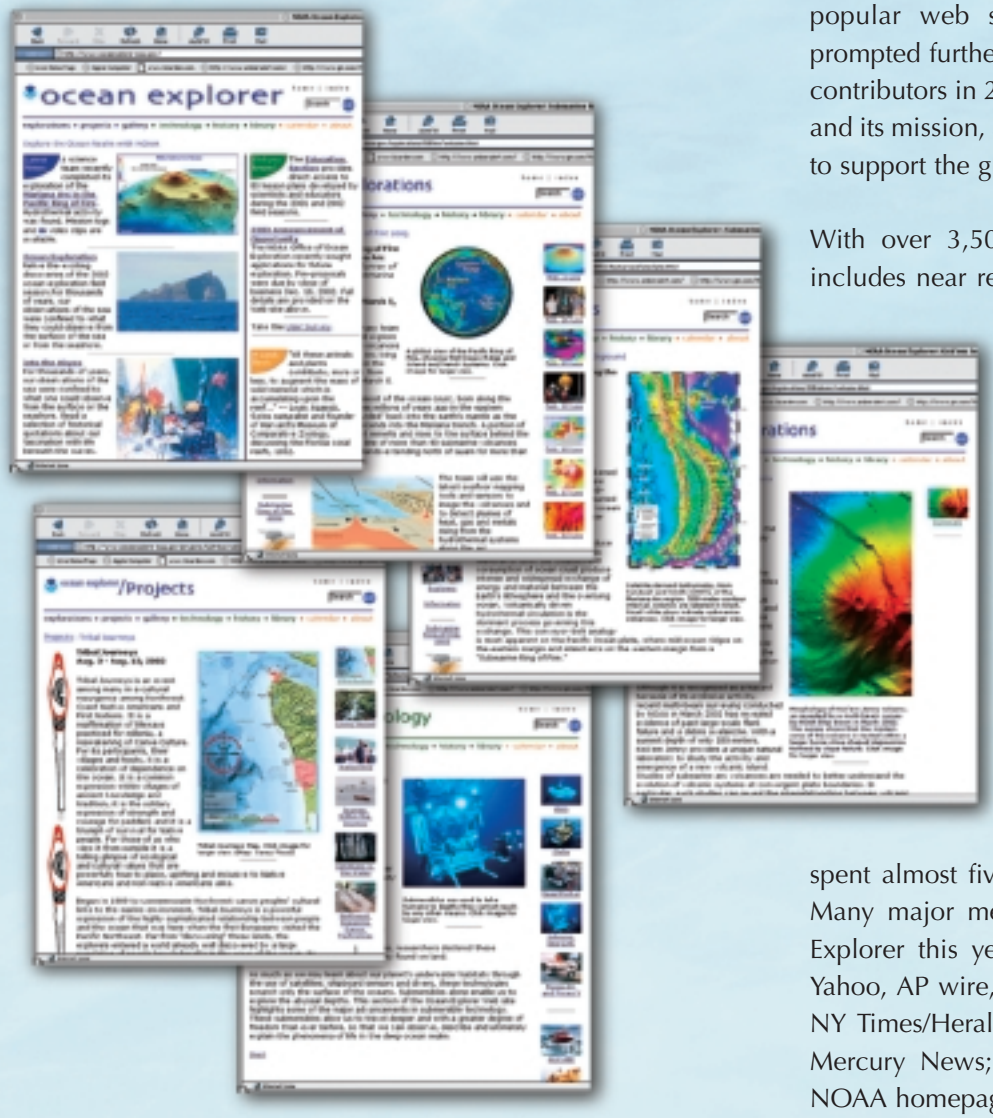
Engaging this expanding audience is not without challenges. In 2002, NOAA organized regional workshops to solicit the needs and concerns of ocean constituents around the country. These workshops provided valuable guidance about regional ocean exploration and science needs, and inspired a number of new exploration partnerships.

OE's program signals a turning point for this Nation's ocean exploration efforts and represents a bold and innovative approach. It infuses teams of multidisciplinary scientist-explorers with a "Lewis and Clark" spirit of discovery, and then equips them with the latest exploration tools. OE has made a commitment to share these 21st century explorations with millions of interested people. Through OE's website and other outreach activities such as radio shows and port calls, everyone can become an ocean explorer.

In 2002, port call events were held in New York City, New York; Kodiak, Alaska; and Charleston, South Carolina. These events gave students, educators, and the media opportunities to visit the vessels and submersibles and talk to mission scientists about the expeditions and the contributions they have made to a greater understanding of the ocean regions.

Another successful outreach venue was through OE's partnership with *Our Ocean World*, a 90-second daily radio program. This show is the only one of its kind that focuses on the issues and splendors of the ocean and airs on over one hundred radio stations around the world. The show presents solutions to shared problems and suggestions on how listeners can help preserve our most vital natural resource.

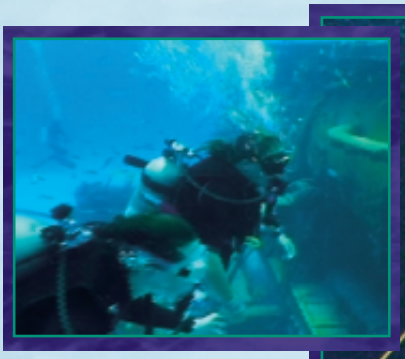
In June 2002, OE successfully participated in Capitol Hill Oceans Week (CHOW) 2002, a bi-partisan series of educational meetings and events highlighting our oceans and coasts. CHOW brought together a wide range of stakeholders to discuss issues relevant to the ocean. An action agenda designed to increase ocean awareness among both children and adults was also highlighted. The event provided a substantive focus on key ocean issues, including emerging ocean technologies and ocean literacy.



In its second year of existence, the Ocean Explorer web site (www.oceanexplorer.noaa.gov) was recognized as a flagship NOAA offering. With more than 4,000 visitors per day, it is one of NOAA's most popular web sites. This growing public profile prompted further improvements to the site. External contributors in 2002 were more familiar with the site and its mission, and eagerly offered their submissions to support the growth and impact of the web site.

With over 3,500 pages of content, the site now includes near real-time daily logs from expeditions, scientific background information on various aspects of ocean exploration, educational materials, historical information on exploration, and a growing library of science publication references and multimedia products including video, still images and biographical sketches of explorers.

Site statistics continue to show a growing audience, including six million visits in August 2002. The average visitor to Ocean Explorer spent almost five minutes surfing during each visit. Many major media outlets featured NOAA Ocean Explorer this year, including CNN.com, LA Times, Yahoo, AP wire, Wall Street Journal, ABCnews.com, NY Times/Herald, Baltimore Sun, and the San Jose Mercury News; it was also the lead story on the NOAA homepage for several explorations.



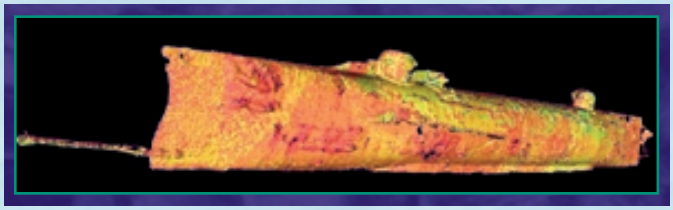
THE AQUANAUTS PROGRAM

The Smithsonian Institution Summer Camp Program partnered with a NOAA exploration team and professional educators for a week of educating and inspiring young explorers in Washington, D.C. The 2002 Smithsonian Associates Summer Camp for Kids program, "The Aquanauts: Exploring the Ocean Depths," gave 10 to 13 year-olds the chance to learn about ocean technology, study marine life, and build a model of the seafloor. This project ran in conjunction with a NOAA expedition to the South Atlantic Bight and gave young explorers a chance to interact with chief scientists and submersible pilots at sea via satellite phone.

THE AQUARIUS PROJECT

In August 2002, NOAA and the Girl Scouts of the USA (GSUSA) teamed up for The Aquarius Project, an intensive week of ocean science and discovery for a nationally selected group of Girl Scouts. This was the first partnership between NOAA and GSUSA bringing scientists and Girl Scouts together for ocean study and exploration. The National Undersea Research Center's (University of North Carolina at Wilmington) Key Largo, Florida field station, home to the world's only underwater laboratory, the Aquarius Habitat, hosted the project. The Scouts learned the fundamentals of exploration, oceanography, ocean technology, coral reef ecology, habitat preservation, and marine biology through hands-on experience and interaction with mentor scientists. These "aquanauts" dove to the Aquarius and visited current mission scientists at work in the habitat (and even delivered boxes of delicious Girl Scout Cookies). They worked alongside marine resource scientists to

monitor fish communities on restored coral reef sites, and conducted an exploration of the Benwood wreck site in the Florida Keys National Marine Sanctuary. Each participating Girl Scout created an outreach plan to present what they learned to their schools, Girl Scout Councils and communities.



HUNLEY

Friends of the Hunley is a non-profit organization dedicated to helping the *H.L. Hunley* complete her historic journey home. The goals of the Friends of the Hunley are to: recover the remains of the brave men who gave their lives and honor them with the proper burial they earned; solve the mystery of the first ever submarine attack in 1864; and conserve one of the greatest, most sought-after artifacts in the history of naval warfare. This year, NOAA partnered with the Friends of the Hunley for the development of new outreach and education materials.

MATE

NOAA partnered with the Marine Advanced Technology Education Center (MATE) and the ROV Committee of the Marine Technology Society (MTS) to co-host the first annual national student ROV competition. The competition is part of a national effort to introduce students to marine science and technology and help them develop the technical, problem solving, and teamwork skills needed in the marine technology workplace. Twenty-two high school, community college and university teams from ten states and Canada participated in an underwater competition of ROV design and capacity. Thirty-three organizations donated funds, equipment, supplies and facilities to ensure the success of this exciting event, while contributing to a growing pool of tomorrow's leaders in ocean technology.

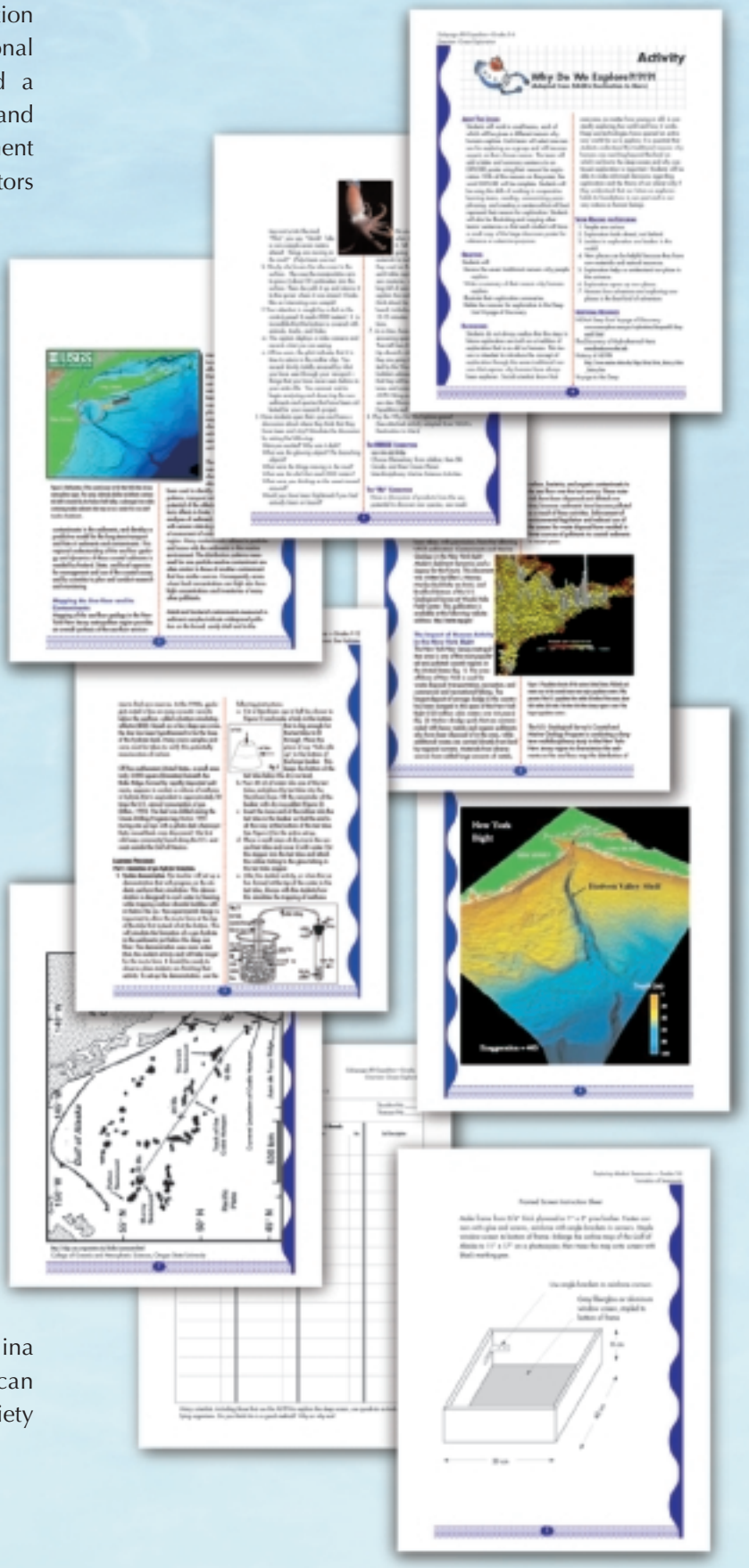
EDUCATION

> *"NOAA helped me connect my oceanography students to authentic exercises and information using the internet."*
>
> -Teacher participant in NOAA's exploration professional development workshop

Achieving increased American environmental literacy requires collaboration between ocean explorers and America's teachers. Working to achieve this goal, new products for educators developed in 2002 included 71 new ocean science and exploration lesson plans for students in grades 5 through 12.

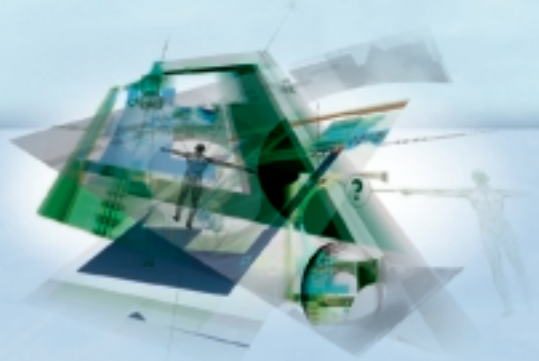
NOAA's Ocean Exploration lesson plans bring entire classrooms "on board" for exploration and discovery using web-based education materials. These lesson plans, developed through partnerships with educators and scientists around the Nation, correspond with OE missions and recently received distinguished recognition from the National Science Teachers Association. Given the NSTA "Scilink" award, these lesson plans have been called exemplary teaching materials by America's largest association of science educators.

In addition to developing lesson plans in conjunction with educators that are correlated to the National Science Education Standards, NOAA provided a number of other significant services to students and teachers. The creation of a professional development program for teachers in four states gave educators access to senior-level ocean scientists and updated their understanding of state-of-the-art ocean technology, research and exploration. NOAA also organized a National Ocean Exploration Education Workshop, bringing together a blue-ribbon panel of more than 50 educators and scientists to guide NOAA's exploration education efforts for maximum effect.



To reach out to educators, the Office published excerpts from the President's Panel Report entitled, *Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration*, in an issue of *Current, the Journal of Marine Education*. Current is the premier publication of the National Marine Educators Association. It reaches over 1,200 educators located throughout the country, including the Hawaiian and Caribbean Islands. Activities for teachers and students focusing on ocean exploration were also included in the publication. OE is also a lead partner in the newly established Southeast Center for Ocean Science and Education, one of seven National Science Foundation funded ocean education centers focused on enhancing and increasing collaboration between ocean scientists and ocean educators.

OE was also represented through presentations at annual meetings of the National Science Teachers Association, the National Marine Educators Association, the South Carolina Marine Educators Association, the American Geophysical Union, the Marine Technology Society and NOAA's OAR Outreach Workshop. ■



ADDITIONAL EDUCATION AND OUTREACH ACCOMPLISHMENTS

- Produced educational and outreach materials for eight voyages of discovery
- Coordinated web development for educational offerings with NOS
- Sponsored Professional Development Institutes in four states
- Produced three lesson plan booklets
- Formed partnership with Building a Presence for Science, an NSTA dissemination network
- Supported MATE ROV Competition and MATE SeaLab
- Represented OE on the NOAA Education Council
- Appointed to NOAA Education Council
- Provided presentations at national and regional conferences
- Partnered with NSF RIDGE Program for joint education workshop
- Partnered with NGS to begin planning of Classroom Exploration of the Ocean, a virtual teacher workshop
- Developed Smithsonian Associates Aquanauts Camp
- Correlated NOAA education posters to NSES
- Partnered with Stephen Low Productions partnership in education
- Hosted National OE education workshop
- Hosted port days in three regions
- Involved in development of NOAA Education Strategic Plan and provided input into NOAA Draft Strategic Plan
- Hosted National workshop lead up to Forum
- Involved with the development of a white paper on ocean science education
- Served on the RI Sea Grant Topical Advisory Team for Education
- Served on the Mote Marine Laboratory Blue Ribbon Committee
- Coordinated SECOSEE partnership in three state region in SE
- Coordinated Hawaii educator partnership in conjunction with NWHI expedition

PHOTO CREDITS

Inside cover – Upper photo: Cirrate octopus *(Stauroteuthis utensis)* Lower photo: Bioluminescent jellyfish *(Periphylla periphylla)* both photos courtesy Harbor Branch Oceanographic Institution.

Page 2 – Pelagic jelly, *Mertensia aboral* courtesy Russ Hopcroft, University of Alaska, Fairbanks.

Page 6 – Upper photo: Lobate ctenophore *(Bathocyroe fosteri)* courtesy Harbor Branch Oceanographic Institution. Lower photo: Pelagic pteropod courtesy Russ Hopcroft, University of Alaska, Fairbanks

Page 7 – Ctenophore *(Bolinopsis infundibulus)* photo courtesy Harbor Branch Oceanographic Institution.

Page 8 – Multibeam mapping images of Explorer Ridge courtesy NOAA.

Page 9 – Spider crab and octopus photo courtesy the Canadian Scientific Submersible Facility.

Page 10 – Students visiting the Harbor Branch Oceanographic Institution submersible *Johnson Sea Link* photo courtesy NOAA.

Page 13 – Upper right photo: Science team loading zodiac courtesy Russ Hopcroft, University of Alaska, Fairbanks. Left small photo: Fluffy copepod courtesy Russ Hopcroft, University of Alaska, Fairbanks. Lower right photo: Arctic expedition team member calibrates an instrument courtesy Emory Kristof, National Geographic Society.

Page 14 – Left photo: Mystery Mollusk courtesy Monterey Bay Aquarium Research Institution. Right photo: gorgonian corals courtesy Monterey Bay Aquarium Research Institution.

Page 15 – Venus Fly Trap anemone courtesy Monterey Bay Aquarium Research Institution.

Page 16 – Science party prepares for *Alvin* dive courtesy Woods Hole Oceanographic Institution.

Page 17 – Lower left photo: Scientist preparing CDT for deployment. Upper right photo: technicians test *Alvin* prior to Galapagos dives. Lower right photo: the *Autonomous Benthic Explorer* (ABE) all photos courtesy Woods Hole Oceanographic Institution.

Page 18 – Left photo: Scarlet king crabs courtesy Woods Hole Oceanographic Institution. Right photo: Alaska Seamounts scientists study collected coral samples courtesy NOAA.

Page 19 – Deep water Paragorgia coral courtesy Woods Hole Oceanographic Institution.

Page 20 – Left photo: Multibeam map image of Explorer Ridge courtesy NOAA. Right photo: ROPOS ROV arm with temperature gauge in hydrothermal vent flow courtesy the Canadian Scientific Submersible Facility.

Page 21 - Upper photo: Octopus resident at Explorer Ridge Vent site. Lower photo: Spider crabs found at hydrothermal vent site. Both photos courtesy the Canadian Scientific Submersible Facility.

Page 22 – Left photo: Giant Isopod collected at Gulf of Mexico site courtesy NOAA. Right photo: Unidentified cold seep community fish courtesy NOAA.

Page 23 – Left photo: Scientist climb aboard the Johnson Sea Link submersible. Right photo: Johnson Sea Link submersible being deployed. Both photos courtesy Harbor Branch Oceanographic Institution.

Page 24 – Left photo: Bioluminescent jellyfish courtesy Harbor Branch Oceanographic Institution. Right photo: Expedition scientists examine rock sample courtesy NOAA.

Page 25 - Upper left: Juvenile scrawled filefish *(Aluterus scriptus)*. Upper middle: A Venus flower basket sponge. Upper right: Juvenile trigger fish (family Balistidae). Lower right: Serpulid tube-worm tubes. All photos courtesy NOAA.

Page 26 – Left photo: Scyphomedusae *(Chrysaora melanaster)* courtesy Monterey Bay Aquarium Research Institution.

Page 27 – Upper left photo: Arctic science team preparing for dives on ice flow courtesy Quing Zhang. Lower left photo: Euchaeta with eggs courtesy Russ Hopcroft. Lower right photo: Diver lowers himself into the cold Arctic Ocean courtesy of Ian MacDonald.

Page 28 – Left photo: Three dimensional map of the Hudson canyon courtesy Rutgers University. Right photo: Bow of the NOAA ship the *Ronald H. Brown* courtesy NOAA.

Page 29 – Upper left photo: Two rattail fish residents of Hudson Canyon courtesy Woods Hole Oceanographic Institution. Upper middle photo: Hudson Canyon expedition team members study new maps courtesy NOAA. Upper right photo: Students visit the NOAA ship the *Ronald H. Brown* during a port call in New York City courtesy NOAA. Lower right photo: Bioluminescent jellyfish *(Pelagia noctiluca)* courtesy Harbor Branch Oceanographic Institution.

Page 30 – Left photo: New multibeam map image of Northwestern Hawaiian Islands. Right photo: The University of Hawaii submersible *Pisces IV* being deployed. Both photos courtesy NOAA.

Page 31 – Upper left photo: Computer console used during multibeam mapping mission courtesy NOAA.

Page 32 – Upper left photo: High Definition Imaging equipment is loaded on *ARGUS,* a tow sled used by Dr. Ballard during the Black Sea Expedition courtesy Institute for Exploration. Lower right photo: The *Klein 5000* side scan sonar resting on deck in its cradle. The unit was used to study possible changes in the seafloor in Bristol Bay courtesy NOAA.

Page 33 – Upper left photo: A three dimensional representation of the Bear Seamount was created using SeaBeam visualization technology. Upper right photo: Moonfish *(Lampris guttatu),* a species about which little is known, is one of the pelagics targeted for the central North Pacific pop-up satellite archival tagging study. Lower right photo: Bivalve samples collected during the Exploration of Heceta Bank including a perfectly intact 14,000 year old mussel shell recovered from the Bank's ancient shoreline. All photos courtesy NOAA.

Page 34 – Upper left photo: The Link Symposium was named after Edwin Link, a pioneer in space and ocean exploration courtesy Harbor Branch Oceanographic Institution. Upper right photo: The NOAA ship the *Ronald H. Brown* preparing for work in the Puerto Rico Trench courtesy NOAA.

Page 35 – Upper left photo: Normandy - The transport vessel, *Susan B. Anthony* was sunk near the beaches of Normandy courtesy Naval Historical Center. Upper right photo: The *R/V Ocean Surveyor* was used to obtain high resoloution maps of the Gulf of Mexico courtesy NOAA. Lower right photo: The French research vessel *Le Suroit* tied up in Ponta Delgada before the SIRENA Expedition courtesy NOAA.

Page 36 – Lower left photo: High definition images of shipwrecks at Thunder Bay were taken this year. Upper and middle right photos: The turret of the *USS Monitor* being recovered. All photos courtesy NOAA.

Page 38 – Upper photo: Jellyfish *(Bathocyroe sp.* Lower photo: Sawtooth snipe eel *(Serrivomer beai).* Both photos courtesy Harbor Branch Oceanographic Institution.

Page 39 – Lower left photo: Girl Scout with secci disc taking measurements of water clarity in the Florida Keys courtesy NOAA. Upper right photo Alaska Seamounts scientist with Kodiak schoolchildren at Kodiak port event courtesy Zach Hoyt.

Page 40 – Oceanexplorer web page samples courtesy NOAA.

Page 41 – Upper left photo: Girl Scout explorers diving on the Aquarius Habitat. Lower left photo: Schoolchildren watch a virtual Hudson Canyon fly-over. Upper right photo: Girl Scouts taking part in the Aquarius Project learn how to use ocean science equipment. Lower right photo: Girl Scouts examining water sample taken during the Aquarius Project. All photos courtesy NOAA.

Page 42 - Upper left and lower left photos: The *H.L. Hunley* is being preserved at the Warren Lasch Conservation Center. Both images courtesy Friends of the Hunley. Upper right photo: Over 100 teams competed in the MATE ROV competition in 2002 courtesy MATE.

Page 43 – Lesson plan example pages courtesy NOAA.

For more information, contact:

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